Chapter 3. *Some Results Obtained by Realising the Cooperative Externalisation Technique with the Aid of a Participant Experimenter.*

This chapter in combination with Appendix B, provides an account of experimental work inspired by the ideas underlying the theory; the theory itself (Chapter 5 onwards) was properly formulated whilst the work was in progress.

1. Introduction

In order to examine the notions mooted in Chapter 2, Section 5, it is first necessary to set up a workable cooperative externalisation technique (CET), since each postulate is evidenced by a transaction or a class of transactions in such a conversational scheme. For pragmatic and operational reasons, the CET systems have often been constrained; chiefly so that they act as teaching or training or testing systems.

The first instrumentation of the CET took place in the context of learning experiments involving small groups of 3 subjects, held in adaptively stabilised conditions and maintaining communication through a mechanical but fairly rich language (capable of expressing descriptions of a universe, questions, ostensions, and proposals of a structural kind; for example, about communication or coalition structures). This is reported in Pask and Lewis, 1962, 1964, 1969, and Lewis obtained further data upon aberrant communication strategies, which will be published during the next year or so. The first serious application of the CET to individual learning slanted, in particular, to the empirical distinction of exclusive learning strategies and bearing witness to the (apparently ubiquitous) effect of cognitive fixity is summarised in Appendix B. In the main text it is only necessary to comment that strategy types, their invariance due to cognitive fixity, the existence of an individual competence to execute a learning strategy of a given type and the salutory effect upon learning of a conversational CET have been observed in the context of a complex perceptual motor skill (Pask and Scott 1971) and that the phenomena in question were predicted and modelled. As the same phenomena occur, reliably, in the context of intellectual skills and bodies of academic knowledge it is conjectured that the processes responsible permeate all facets of the psyche.

2. Experiments

The bulk of this chapter is an account of some early but (so more recent results indicate) representative experiments (Pask and Scott 1972). These studies illustrate a non-mechanised form of CET using a restricted type of English as the conversational "object language". They also show that it is possible to predict, test for, and distinguish strategy types and individual competence. The main strategy types, serialist and holist, (by no means the only ones) are mental parodies of the organisation in computer programs like Newell, Shaw and Simon's "General Problem Solver" (Ernst and Newell 1967) and the "Teachable Language Comprehender" (Quillian 1969). Finally, the studies illustrate the notion of "Teachback" or (equivalently) of giving an explanation (of a topic) with which some other participant agrees; here the other participant in the CET system is a *participant* experimenter. By hypothesis, such a sequence of explanations corresponds to the reproduction of a reproducible concept for the topic in question. Such events will later be called *understandings* (of a relation, by given participants) and the existence of understanding is taken to signify the existence of a memory of a concept, in the sense of Chapter 2, Section 5.

2.1. *Strategies.* Two major categories of mental competence reflect an individual's cognitive style and lead him, in free learning conditions, to prefer a certain type of strategy, i.e. to direct his attention in a specific way to different parts of a learning task, to ask specific sorts of questions, to assimilate material by specific types of "self explanation" and to pose specific sorts of hypotheses.

The two major categories of individual are called serialists and holists. This distinction was first made in the context of a relation learning task (Appendix B) but it has been found equally germane in connection with intellectual tasks. These categories are quite commonsensical and would be evident to many experienced teachers. Although the categories can be empirically adduced, it is also possible to predict their existence on the basis of the present theory of learning and teaching.

Serialists learn, remember and recapitulate a body of information in terms of string-like cognitive structures where items are related by simple data links: formally, by "low order relations". Since serialists habitually assimilate lengthy sequences of data, they are intolerant of irrelevant information. Holists, on the other hand, learn, remember and recapitulate as a whole: formally, in terms of "high order relations".

There are two subcategories of holists called irredundant holists and redundant holists. Subjects of both types image an entire system of facts or principles. Though an irredundant holist's image is richly interconnected, it contains only relevant and essential constituents. In contrast, redundant holists entertain images that contain logically irrelevant or overspecific material, commonly derived from data used to "enrich" the curriculum, and the salient facts and principles are embedded in a network of redundant items. Though logically irrelevant, the items in question are of great psychological importance to a "redundant holist", since he uses them to access, retain and manipulate whatever he was originally required to learn.

An individual's competence can be determined under "free learning" or "browsing" conditions by a questioning and goal selecting procedure used to externalize his mental process as an observable stretch of behaviour. The free learning technique has the following general properties. Prior to free learning the subject is introduced to the task goal (e.g. learning a zoological taxonomy) and reads through an introductory and irredundant description of the system. The taxonomic system and its universe of discourse is redundantly described by five categories of statements which are inscribed on cards placed in separate piles according to their category. The student learns by "questioning", i.e. by turning up cards and (if he wishes) generating new "cards", via note taking. He is given a limited period in which to work but he is free to ask any question provided that he states a reason for doing so. The "questions" asked, the reasons for asking them and the notes taken (and counted as "fresh cards") are all recorded. The reasons can all be summarized under one of the following headings:

(i) to "search a co-ordinate of the message space", i.e. to pass through a pack of cards as though thumbing over the pages of one chapter in a book; (ii) to "search for a datum regarding a particular object, specimen, fact, etc., named independently of the card-category co-ordinates"; (iii) to "test an hypothesis about a simple predicate" (for example, that a specimen in Class X has more than two legs); (iv) to "test an hypothesis about a complex predicate" (for example, that Class X differs from Class Y in respect of leg number and mating behaviour or habitat).

The serialist differs from the holist chiefly in terms of the complexity (order) of predicates involved in the hypotheses he tests. A redundant holist differs from an irredundant holist in terms of his question distribution amongst the card-category co-ordinates. Success and failure in a subsequent test are correlated with the ratio of the number of hypothesis testing questions to the number of searching questions uttered during free learning.

The competence type assigned on the basis of a student's free learning characteristics checks out against a content analysis of the dialogue during an interview-like or tutorial procedure in which each student "teaches back" to the experimenter whatever he has learned.

2.2 *Matched and mismatched conditions for teaching and learning.* Any piece of educational material, a textbook, a course module or a teaching programme, is based upon a teaching strategy. The teaching strategy is analogous to the learning strategy used by a student to direct his attention during free learning except that it is imposed by the teacher or course designer rather than generated by the student himself.

Teaching strategies can be slanted to suit an individual with a given sort of competence. For example, a teaching strategy can be designed with a serialist in mind, or a holist.

The theory prescribes quite accurately, what sort of teaching strategy will suit a given type of individual. In the sequel, "serialist materials" and "holist materials" mean materials structured according to these principles.

Since human beings are highly adaptable it may be possible for an individual with any sort of competence to learn, in the end, according to any teaching strategy. But the experiments show, very clearly indeed, that the rate, quality and durability of learning is crucially dependent upon whether or not the teaching strategy is of a sort that suits the individual, i.e. upon whether the conditions (Fig. 1) of learning are "matched or mismatched".

Whereas matched students learn effectively (near perfectly) the mismatched students do not do so (and retain hardly any

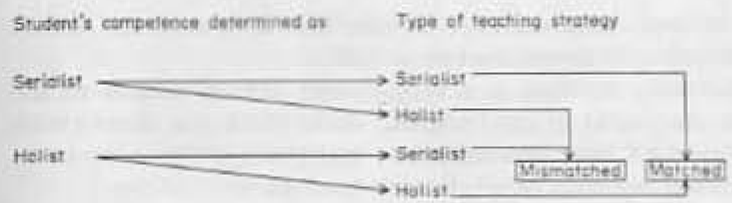

Fig. 3.1. Comparisons made.

ungarbled knowledge). This assertion is based on molar test data; for which the appropriate comparisons yield differences significant at the 0.1% level for groups of N = 8 each. The differences evident on examining the molecular data, which indicate why the distinction exists, are even greater.

One experimental design is shown in Fig. 2. The treatment takes place over two experimental sessions [(I) and (II)] separated by about two weeks, during which two similar tasks are used (both of them "learning a taxonomy of unfamiliar objects", called "Martian Fauna"). The content of each task is roughly one lesson's worth: Task 1 corresponds to a medium-sized (approx. ½ hour) lesson and Task 2 corresponds to a long (approx. 1 hour) lesson.

The first session (I) establishes the competence of an individual student; as a result he is assigned, on the second session (II), to a matched or a mismatched group. The tests are conventionally

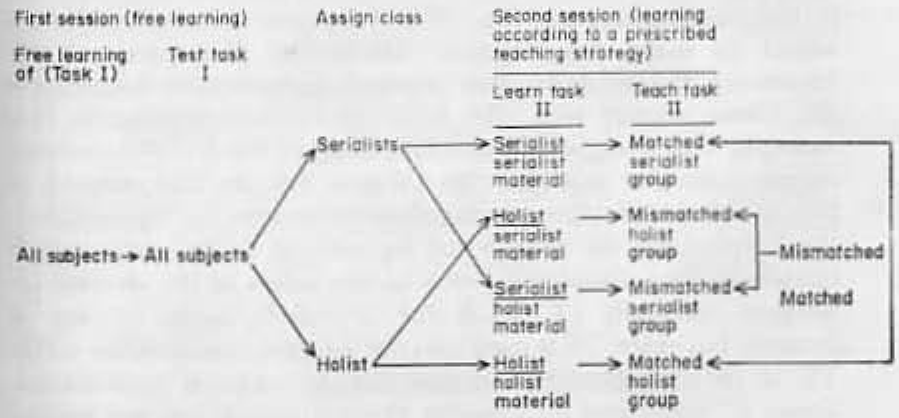

Fig. 3.2. Outline design.

marked 30-item questionnaires tapping factual knowledge (about 80%) and ability to generalise (about 20%).

The following account is a very heavily edited version of the procedure employed in one (original) study (Pask and Scott 1972) but is typical of later investigations and (with differences to be pointed out in context) of all strategy type discriminations.

Task (I) is to learn the "clobbits" taxonomy. It is noteworthy that any zoological taxonomy (in fact any taxonomy) can be learned and manipulated in various ways. For example, though a novice is instructed to use the classification rules in an orderly fashion, the expert unashamedly recognizes the member of a species by diverse, though relevant, criteria. This possibility comes about because there are many relations between subspecies which can be expressed independently of the taxonomy; because there are relations of symmetry, asymmetry, complementation, etc. within the given taxonomic tree; and because there are many alternative ways of making a pertinent distinction between subspecies. For example, the subspecies might be distinguished in terms of the physical variables which generally (and, in this case certainly) are tested in the taxonomy itself; by differences in the behaviour of the animals concerned or by contextual information; for instance, regarding the habitat of the animals or the historical origins of the classifying nomenclature. This degree of richness is and must be embodied in useful test Tasks. Learning one of them is not simply an arid and abstract exercise.

In Task (I) there are 10 subspecies of "Clobbit" with two main subtypes, "Clobs" and "Bits". There are 9 test boxes or branches in the classification tree (Fig. 3) and 7 physical characteristics are tested to make the requisite distinctions. For parts of the taxonomy, the values of other physical characteristics discriminate the classes equally well. The structure contains symmetries (for example, four 4-legged Bits and four 3-legged Bits); it also contains asymmetries (for example, the 4-legged Bits are first assigned to two subspecies yielding one and three subspecies (by leg position); the 3-legged Bits are assigned by leg position to two subsets each containing two subspecies. Some of the names of the animals are assigned rationally (T stands for Triped; K stands for legs at corners, but since TK is used only for 3-legged creatures the suffix TK is redundant). Some names have no rational justification. There is background information about the behaviour and habitat of the clobbits, some of which is relevant to the distinctions made

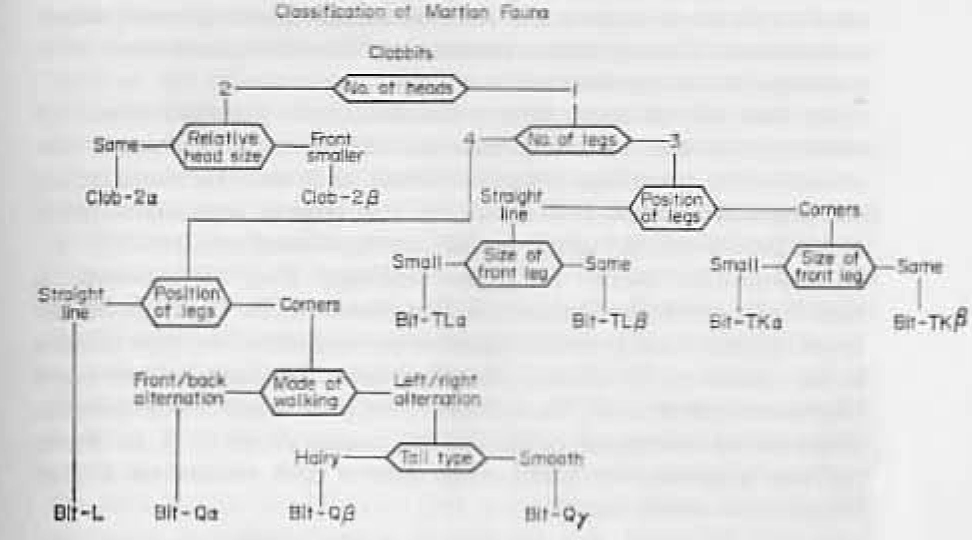

Fig. 3.3. Clobbit taxonomy.

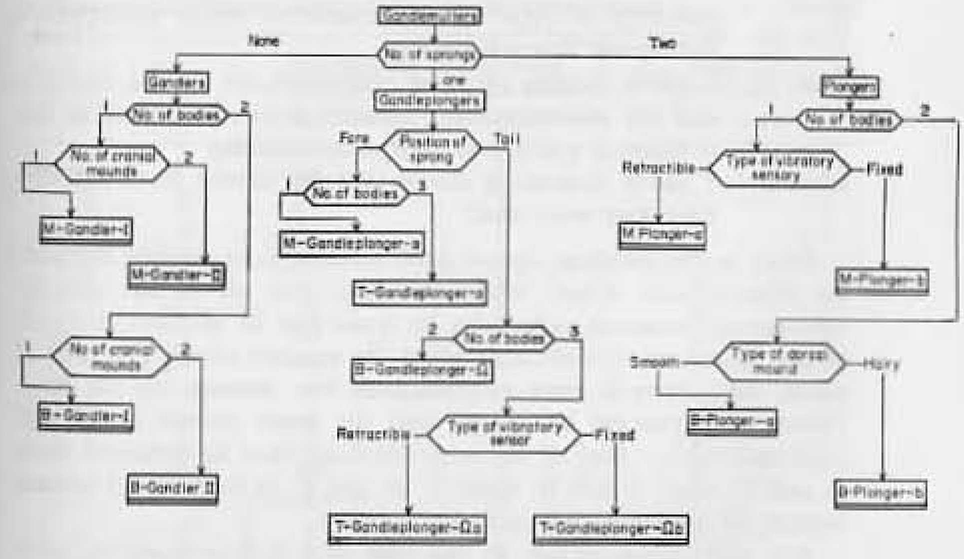

Fig. 3.4. Gandlemuller taxonomy.

(and might be used to make them redundant) and some of which is irrelevant. Finally, each subspecies of Clobbit is associated with a picture of one member of it.

In Task (II) students learn a taxonomy of "Gandlemullers" of which there are 13 subspecies and three main subtypes. The classification tree (Fig. 4) has 11 "tests" or branch points entailing six physical characteristics. All of the general comments made about the "Clobbits" apply equally to the "Gandlemullers".

Information about the (free learning) Task (I) universe is written on cards that belong to five classes A, B, C, D, E. On the front of each card is a statement which specifies the type of data to be found on its reverse (or face) side. The cards are arranged face downwards in a five-column array in which each column contains the members of one of the classes A, B, C, D, E. Every column is labelled to indicate the class of data written on any of the member cards, namely:

Class A 10 cards showing pictures of a typical member of a Clobbit subspecies;

Class B 13 cards giving contextual information about the appearance, habitat, or behaviour of these animals;

Class C 5 cards stating the structure of the taxonomy. Each card names the members of a subspecies and states the numbers of physical characteristics tested in order to distinguish this subspecies;

Class D 7 cards naming physical characteristics of the clobbits and the values assumed by each property on each of the subspecies which it is used to distinguish;

Class E 7 cards indicating the subspecies names or codes and why they were used.

Prior to free learning, the student is oriented by reading through an introduction which states the goal and all of the strictly relevant information. After this, he is allowed 25 minutes in which to ask questions. To ask a question the student selects one card at once, and turns it over to scrutinize the message on its face. During this process he knows that the cards convey redundant information, i.e. that all the requisite data could be obtained from A and C; from A and D; from C, D, and E; or from B and certain subsets of the remaining cards in the array.

For each question (or, in the case of a coherent search, each sequence of questions) the student is required to give a reason for

asking the question concerned and his reasons are tape-recorded. The time occupied in giving reasons is not deducted from the time allowed for questioning. Only four sorts of reason were actually given (i) search a card class or co-ordinate of the message space; (ii) search for a specific datum; (iii) test a single predicate hypothesis; (iv) test a multiple predicate hypothesis.

Of these, the occurrence frequency of type (iv) reasons is used to discriminate serialist and holist competence, for which purpose it is unnecessary to enquire what hypothesis is being tested. The form of the hypotheses is specified within the framework afforded by the array and the four categories of reasons for questioning.

It is predictable, from the theory, that holist mentation will be discriminated from serialist mentation by the occurrence, in free learning or in teachback, of tests for hypotheses based on complex predicates rather than simple ones. Due to the unitary nature of the tests in the classification tree a simple predicate hypothesis is probably a single predicate hypothesis and, given this identification, the discrimination is clearcut. Table 1 is the "analysis of reasons" on which the initial assignment of competence type was based.

TABLE 3.1
Molecular data from free learning session (1). Competence type assignment based on type (of predicate) in hypothesis

		Information seeking transitions	"Small" predicate in hypotheses	"Large" predicate in hypotheses
Serialist	1	19	3	0
	3	10	7	0
	4	37	0	0
	6	20	0	0
	8	9	9	0
	10	26	6	0
	12	18	1	0
	16	18	5	0
Holist	2	10	8	8
	5	21	2	13
	7	22	8	5
	9	8	2	14
	11	8	2	10
	13	7	5	9
	14	11	0	8
	15	20	0	5

By way of a summary, the competence types are associated with the following behaviour patterns.

(a) An Irredundant Holist sets out to find the overall form of the classification tree and to locate its tests; typically he garners this data from classes B, D, or E. He sets up (usually complex predicate) hypotheses about the values of the physical characteristics of each subspecies and tests them by inspecting picture cards in Set A.

(b) A Redundant Holist scans through cards of many or all classes. He bases complex hypotheses mostly on the subspecies names or codes of Set E cards (for example, that some creature is 3-legged and 1-headed and has a short front leg and has a bushy tail) and tests them by inspecting cards in Set A.

Holists, either irredundant or redundant commit mistakes due to simple over-generalization (for example, that (β) always implies "Bushy Tail" which is true for only some subspecies) or systemic over-generalization to render the classification scheme more rational or symmetrical than it actually is (for example, falsely naming a subspecies "Bit QL" on the evidence that Q stands for "4-legged" and L stands for "Linear" together with the valid inference that a 4-legged linear creature exists).

(c) A Serialist is prone to list the subspecies by examining picture cards in Class A. If he is to be successful, he checks the relevance of the information entering his list by forming single predicate hypotheses (for example, that a BIT L has 4 legs) and testing them by inspection of the cards in set D or C. A structure is thus built up in orderly stages.

Serialists fall into difficulties if they fail to distinguish the wood from the trees and consequently try to assimilate masses of sparsely related irrelevant information. The most marked manifestation of this failing is an attempt to list all features of the picture cards in Class A. But, even if relevance is determined systematically, the serialist strategy appears to impose an appreciable load on storage capability. Some students who accumulated all the relevant data failed, subsequently, to reconstruct the entire taxonomy.

The test administered after free learning the initial task was a 30-item questionnaire. Test scores are shown in Table 2.

Achievement at Task (I) was again tested at the beginning of Session (II). The test scores are shown in Table 2.

TABLE 3.2
Molar Data

Subject Number	Clobbit [Task (I) Test			Gandlemuller [Task (II)] Test		
	1st session (max 30)	2nd session (max 30)	2nd and 1st score difference	Task II test	Student type	Programme type
TB 1	13	30	+	9	S	H
TB 2	25	27	+	21	H	S
3	25	17	—	29	S	S
TB 4	10	28	+	7	S	H
5	27	23	—	30	H	H
6	15	10	—	9	S	H
TB 7	27	30	+	30	H	H
8	27	18	—	28	S	S
TB 9	28	30	+	30	H	H
10	17	13	—	30	S	S
11	23	19	—	19	H	S
TB 12	18	30	+	9	S	H
13	21	25	+	30	H	H
14	26	17	—	16	H	S
TB 15	21	28	+	20	H	S
16	22	17	—	29	S	S

Task (II) is to learn a taxonomy on the universe of "Gandlemullers".

This universe is also redundantly described by a set of cards, (also used to generate the serialist and holist teaching programmes employed for instructing Task (II)). Both of the programmes convey exactly the same strictly relevant information, knowledge of which is subsequently tested. Both of the programmes have a linear presentational format (the serialist programme has 11 information and test frames and the holist programme has 25 information and test frames). But the concepts they instruct are different and very differently structured.

The holist programme is designed for a redundant holist and it defeats a serialist student. A programme designed for an irredundant holist might not have done so and this might have given rise to a less marked distinction between the matched and the mismatched groups.

The serialist programme refers to a kernel of strictly relevant concepts which are presented in an orderly and logical fashion. It defeats a redundant holist and offers a difficult (and incidentally, unpalatable) learning experience to an irredundant holist, though students with this competence do eventually come to grips with it.

Both programmes were administered in the same way with the following instructions and criteria for advancement. Recall that both programmes are in a linear format, and thus consist in a series of information and test frames.

(1) At the nth frame, $n = 1$, the subject is asked to read slowly through the information frame (actually, a card of the sort used for questioning and answering during the free learning task).

(2) When the subject has finished, he is presented with a test frame (a card containing questions and blank spaces to fill in).

(3) If the subject responds correctly, he is presented with the $n + 1$th information frame (unless the nth frame is the last, when step 6, below, is executed).

(4) If the response is mistaken, the nth information frame is presented and read once again.

(5) The cycle is repeated so that a subject does not advance to the $n + 1$th frame until his response to the nth is correct in all particulars.

(6) On completion of the programme, the student either has or has not completed an error free run. If he has done so, the procedure terminates.

(7) If any error has been committed the entire programme is repeated until such moment as the criterion stated in stage 6 is satisfied.

(8) Since the procedure is cyclic, all students are eventually forced to complete one run of the programme to which they are assigned without any overt mistakes.

Let us emphasize that satisfaction of this criterion does not imply that a student has learned the taxonomy even though he gives the appearance of mastery and even though criteria of this type are often believed to indicate mastery is attained.

The student's knowledge is next tested by means of a 30-item questionnaire. The test scores obtained from holists and serialists who received instruction via a matched mode (holist/holist programme; serialist/serialist programme) or via a mismatched mode (holist/serialist programme; serialist/holist programme) are shown in Table 2.

The final event in Session (II) is the elicitation of "teachback" the results of which are recorded and content analysed.

2.3 *Teachback and concept Explanation hypothesis.* An ability to retain complex information over an appreciable period depends upon a cognitive process of reconstruction (the reproduction or self-explanation of the concept in question).

The practical consequence of the "concept reproduction" hypothesis is that conventional test scoring methods of examination are unlikely to discriminate between students who have and have not learned a concept. Rather than taking an examination, students should show evidence that they can reproduce the required concept in a conversation with a tutor (the participant experimenter) during which the concept reproducing process can be externalised for observation as the student "teaches back" the concept he has allegedly learned.

It is true that the act of doing so is likely to teach him the concept in its own right and, to this extent, it is impossible to separate testing and teaching. For educational purposes, the confusion is unimportant; after all, the object of education is to teach somehow. But it does mean that an experiment can only discriminate the subsequent retention of students who have demonstrated an ability to teachback with the retention of students who have been subjected to a comparable experience ("ineffective teachback") in which part of the reconstructive cycle is deliberately omitted.

After free learning Task (I) all students were subjected to one or other version (a) or (b) of a teachback procedure.

Half of them were randomly assigned to a real teachback (unqualified teachback) defined thus:

(a) the student is asked to teach the experimenter how to use the taxonomy on the assumption that the experimenter is a person of the same mental make-up as the student himself but is omniscient with respect to all relevant aspects of the task (i.e. to all items that appear in the test and all items, derivable from the irredundant introduction that might appear in the test). On completing the teachback any mistakes or omissions are corrected and the student is asked to reconstruct his teachback so that they are eliminated. The cycle of correction and reconstruction is repeated until no errors or omissions remain in the teachback.

Half of the students were randomly assigned to an ineffective teachback (b) defined thus:

(b) the student is asked to teach the experimenter how to use the taxonomy on the assumption that the experimenter is a person of the same mental make-up as the student himself but is omniscient with respect to all relevant aspects of the task. On completing the teachback any mistakes or omissions are noted and the student is furnished with knowledge of results that corrects each mistake (or omission) and states why the response was mistaken or how an omission is related to the body of the taxonomy. The student is now tested over omitted or mistaken items (he is not required to teachback again) and knowledge of results is furnished with respect to each mistaken test response. The cycle of correction and testing is continued until no errors or omissions remain.

After learning Task (II) (taught by a matched or a mismatched teaching programme) all students were subjected to a further teachback routine. In this case, the object is not to establish a distinction between "Teachback" and "Ineffective Teachback", but to check the competence assignment and to elucidate the influence of matched and mismatched instruction upon a student's mental organization.

Some typical "Teachback" protocols are set out in Appendix C. The differences between students and the cognitive dilemmas they encountered are apparent from an inspection of this data. To quantify them, two sorts of analysis were conducted, the results of which are shown in Table 3 and Table 4.

The first analysis (Table 3), is a content analysis of the number of occurrences of:

(a) falsehoods;

(b) corrected falsehoods;

(c) inventions (items imported from outside the described universe);

(d) anticipatory statements about what is to come later;

(e) deductive statements;

(f) irrelevant statements (i.e. those that are irrelevant to the required body of knowledge);

(g) redundant statements (i.e. those that overspecify this body of knowledge);

(h) the total number of statements analysed for a given subject.

The second analysis (Table 4) is a teachback order analysis showing the extent to which a student's self-constructed teachback of the concepts he has learned departs from the order in which these concepts were presented by the teaching programme

TABLE 3.3
Content analysis of teachback protocols (Task II)

	Subject No.	Falsehoods/corrected falsehoods	Inventions	Statements of information to come or delivered	Statements deduced	Irrelevant	Redundant	No. of statements — total (excludes interjections, repetition or corrections)	Student	Material	
Serialist with serialist programme	9	0	0	0	0	0	0	29	Serialist	Serialist material	Matched students
	8	1/1	0	0	0	0	0	28			
	16	1/1	1	1	1	0	0	41			
	3	1/0	0	3	1	0	0	47			
Holist with serialist programme	14	1/1	0	0	7	0	0	37	Holist	Serialist material	Mismatched students
	11	2/1	0	8	4	1	0	33			
	2	0	1	2	7	1	0	26			
	15	3/1	0	1	4	0	0	34			
Serialist with holist programme	1	2/0	0	1	0	11	2	39	Serialist	Holist material	Mismatched students
	12	3/1	0	0	0	7	0	28			
	6	4/1	0	0	0	14	3	42			
	1	6/0	1	0	1	20	4	48			
Holist with holist programme	5	0/0	1	5	3	9	0	66	Holist	Holist material	Matched students
	9	1/1	1	12	5	5	0	70			
	7	1/1	2	13	1	23	3	110			
	13	2/1	6	17	10	23	24	116			

to which he was assigned. The tabulated numbers are frame numbers in the respective teaching programme (holist or serialist). The order of the tabulated numbers depicts the sequence in which the numbered concepts were evoked during teachback.

TABLE 3.4
Teachback order in relation to programme frame No.

	Subject No.	
Serialist with serialist programme	9	1→2→3→4→5→6→7→8→9→10→8→11
	8	1→2→3→4→5→6→7→6→7→8→9→10→11
	16	1→2→3→4→5→6→7→8→9→10→11
	3	1→2→3→4→5→6→7→8→9→10→11
Holist with serialist programme	14	2→1→4→6→8→1→2→4→6→8→9→10→4→5→$\genfrac{}{}{0pt}{}{6}{7}$→8
	11	1→2→1→9→2→3→4→5→7→11→8→$\genfrac{}{}{0pt}{}{9}{10}$→11
	2	1→2→4→6→8→2→8→2→3→8→1→7→5→7→4→6
	15	1→2→1→2→3→4→6→8→4→5→6→7→9→10→9→11
Serialist with holist programme	1	3→4→6→10→11→12→7→8→9→15→9→21→11→13→14→ 23→24→25
	12	1→2→3→8→4→5→6→10→11→12→13→8→15→16→18→ 20→24
	6	1→2→3→4→6→5→3→10→11→12→8→9→10→11→12→$\genfrac{}{}{0pt}{}{15}{20}$→ $\genfrac{}{}{0pt}{}{18}{24}$→25
	4	1→3→5→4→$\genfrac{}{}{0pt}{}{6}{12}$→11→15→16→20→9→16→18→11→13→14
Holist with holist programme	5	1→3→1→6→5→4→15→16→18→20→13→14→7→15→18→ 20→18→15→20→23→24→13→10→11→12→13→14→24
	9	1→2→1→5→7→8→10→11→12→$\genfrac{}{}{0pt}{}{13}{14}$→5→15→18→22→18→ 20→23→22→24
	7	1→2→7→8→1→3→9→18→19→10→11→13→14→10→1→ 6→15→18→23→5→15→18→5→12→13→14→23→10→11→ 12→13→14→15→16→18→20→23→24
	13	1→6→5→7→8→10→3→7→11→12→6→5→15→18→10→ 15→4→16→15→10→16→15→6→18→20→22→19→23→ 12→13→14→23→5→24

2.4 *Discussion of main results.* Table 1 (Task (I) free learning data) indicates a clearcut distinction between serialists and holists in terms of "complex" or "large predicate" hypotheses. The distinction is heightened by taking the nature of the hypotheses into account and, in this case, it is also evident that the type of single predicate hypotheses tested by the serialist differs from the

type (of single or complex hypotheses) tested by the holist. There is also a positive correlation between success and the total number of hypotheses tested.

The same assignment can be made in terms of the Task II teachback data (Tables 3 and 4). In Table 3 (content analysis) holists are distinguished from serialists in terms of the number of inferential statements they produce where an inferential statement is either an anticipatory statement or a deductive statement. In Table 4 (teachback order analysis) it is possible to distinguish the serialists from the holist by a tendency, on the part of a serialist, to preserve the order of the programme presentation format which is absent in the holist. Presented with a holist programme the serialist is unable to preserve the complete order but he does manage to preserve sequentially arranged fragments.

The gross data (test scores for holists and serialists, matched and mismatched) are shown in Table 2. First, it is quite evident, on examining the Task (II) test scores, that matched students learn more efficiently than mismatched students. Since the rankings do not overlap a statistical test is gratuitous but, as a formality, the difference between matched students N = 8 and mismatched students N = 8 is significant (in favour of the matched group) at the 0.1% level of significance (0.001 > P) using the Mann–Whitney U-test. The same comments apply to an intergroup comparison of the ratios:

$$\frac{\text{Task (II) Test Score (Session II)}}{\text{Task (I) Test Score (Session I)}} \times 100\%$$

Comparing the (N = 4) mismatched holists with the (N = 4) mismatched serialists there is a difference in favour of the holists, at the 1% level (0.01 > P) which is believed to reflect the fact that an irredundant holist can (with difficulty) learn from a serialist programme. In fact, those mismatched subjects classified as irredundant holists learned the task after 4–7 repetitions of the serialist teaching programme, compared with the 1–3 repetitions required by (matched) serialists. There is no significant difference between the scores achieved by matched serialists and matched holists (i.e. either strategy can be employed successfully).

The influence of teachback on learning Task (I) is reflected in the test scores achieved for Task (I) at Session (II) (after the teachback experience of Session (I)). Comparing the scores of the (N = 8) students receiving a real teachback experience (marked

TB) with those of (N = 8) students receiving ineffective teachback there is, once again, no overlap in the ranking and the bias is strongly in favour of teachback.

The difference in question is significant at the 0.1% level (0.001 > P) using the Mann—Watney U-test.

2.5. *Outstanding matters.* How general are these results? Subsequent experiments using the same taxonomic material (chiefly as a test for strategic disposition) bear out the major distinction over a sizeable number of different subjects (50 or 60); within the context of a conversation on the same topic the distinction is as sharp as supposed and further distinctions (like redundant/irredundant holist) also seem to be tenable. It is especially gratifying to find that the choice of strategic categories, once described, meets with general approval amongst adult-teachers as well as school-teachers; it is rarely deemed capricious. There is now a good deal of evidence that a disposition to adopt one kind of strategy characterises an individual over several areas of learning. We have recently studied learning strategies with respect to entirely different topics (the mammalian oestrous cycle, the concept, in molecular biology, of an "operon", principles of courteous motor car driving) and find (Pask, Scott, Kallikourdis et al. 1973) that most individuals are "true to type" over all areas of knowledge tackled by academic or ritualistic learning. Moreover tendencies can be determined, quite reliably, by short and easily administered tests.

On the other side of the coin, it appears necessary to develop the theory in several directions (or to use rather more of the possible predictions). First, there is a factor of versatility (that some people have and others do not have) to change strategy in the light of information gleaned from a learning experience or given as special advice. The factor is known to depend upon the degree of cognitive fixity manifest in learning; more accurately, upon the rate at which fixity develops in a tutorial conversation. But there are strong indications that a specific strategy-constructing skill is also involved and the matter is closely bound up with the ease of "learning to learn" (to be discussed in the sequel).

The notions of competence and strategic disposition are also undergoing revision which has led to a theory of "individuation" (Chapter 5 and Chapter 6). Broadly, it is quite possible to regard

competence as an index of efficiency, in executing strategies of different types, that is carried around with a person. But, it may be the case that it is carried around by a brain, qua processor of data (perhaps competence is innate, perhaps acquired by physiological conditioning) or is carried around by a role (the role of "student", for example) that corresponds to a cluster of procedures which may or may not be in one to one correspondence with a brain (thus, one brain may house the role "student" at one instant; the role "racing driver" at the next); or conversely the role "student" may depend, for execution, upon the existence of processors other than a particular brain (other brains, groups of them, or even inanimate processors). Similar comments can be made about the location or the attachment of a disposition to adopt a strategy of one type and of the self awareness of competence that, in well versed learners, brings strategic disposition into register with the strategy which may be most competently executed. These somewhat enigmatic remarks will be clarified and discussed in the sequel.

Finally, the reader probably feels that more data is needed in respect of the understanding hypothesis; that an explanation of an explanation is evidence of a memory for a concept in the sense of Chapter 2, Section 5. The difficulty, already stated, is that although understanding can be shown in a very precise sense to engender memory *always*, it is impossible to exclude private reproductions or reconstructions of a concept that are not observed as understandings. Two kinds of evidence support the thesis, even so.

First, it is possible to systematically and differentially prevent memorisation even though, in one sense, the data are available. For example, studies of street map recollection with specific interference and of learning materials, some of which have been deliberately devised as immemorable, buttress this contention. The other kind of evidence comes from much larger and lengthier learning experiments (the main example, used from Chapter 4 onwards, is of learning probability theory). Under the conditions needed to carry out such an experiment, at the micro level already described, the subject matter structure is made explicit. A large body of knowledge is represented to the participants in a theoretically memorable form. In practice, it consistently is learnable and memorable.

2.6. *Development of techniques.* Experiments (or tests or tutorial sessions) of the type described in this chapter are laborious but marginally possible. If the topic of the CET conversation is extended to cover a few days worth of continual study or the equivalent content of a two month course the arrangement is completely unmanagable. Moreover, the English language dialogue is, in many ways, embarrassing; it lays the results open to criticism from anyone who has not seen the experiment in progress and the personality biases that do exist are prone, in the long run, to hinder rather than help the student. It was thus decided to employ a language, with rather greater richness than the stilted form of English actually employed by the participant experimenter, which is mechanised as part of an experimental facility.

The facility is called CASTE (Course Assembly System and Tutorial Environment). It is described, after some orientating and recapitulating preliminaries, in Chapter 4. The participant experimenter is usually replaced, in this facility, by a CET heuristic or a tutorial heuristic (Chapter 1, Section 1.5) or, rather, the CET heuristic or tutorial heuristic is executed by a processor consisting of a general purpose computer and a collection of special purpose equipment. The heuristic is one participant, and the subject is another participant. The knowables are represented to both participants by a dynamic and continually visible display. The CET heuristic underlies any tutorial heuristic (as in Chapter 1, Section 1.5 the latter heuristic is a specialised form of the CET) and it will be shown that operation of the CET heuristic guarantees a series of occasions on which (in the framework of an experimental contract) there are understandings. Hence, the system is relativistic; the external observer examines Participant A relative to Participant B in the context of a conversational domain.

2.7. The mierotheory underlying a relativistic psychology consists in a theory of conversations (which is discussed in Chapter 5 and Chapter 6 together with a subtheory of participants) and a theory of knowledge and tasks that may be done (Chapter 7, Chapter 8 and Chapter 9).

To get the discussion under way I shall make some intuitively plausible statements which, on closer inspection, are of a very dubious nature. None of them has an exact meaning at the moment, though all of them are eventually made precise. Their immediate but superficial reasonableness is chiefly due to the fact that they bear upon facets of the previous discussion.

First, it is maintained that any psychological experiment is a conversation between two or more participants A and B on a series of topics that form a conversational domain. Most of the argument deals with conversations between two participants. Only one participant (A) is a respondent (the word "subject" is avoided henceforward, since it is also necessary to use "subject matter"); the other, (B), is a participant experimenter or agent. For example, A might be an interviewee: or an examinee: B an interviewer or an examiner. Or A might be a student and B a teacher; if so the conversation is a tutorial. This is an important case in its own right. But, whether or not A and B have the official status of student and teacher, it is invariably true that they learn as a result of conversing about the domain (this is a condition; the domain contains something to be discovered or learned about, whatever roles such as respondent/interviewer or student/teacher are assigned to A and B). Although A is always human and B may be human, there are interesting cases, which are stressed because of their clarity, in which B is executed by a machine. In either case the A, B conversation takes place across an interface which separates A and B, which serves as their communication medium and at which position an external observer (in contrast to a participating experimenter in the role of B) may scrutinise and record A, B transactions.

The conversation takes place in a potentially formalisable language L. Although L can be a spoken or written language, in the special and clearcut cases where B's role is executed by a machine L is a mechanical language. If so L expressions typically consist in sequences of graphic displays, signalling events, or responses such as building a model, solving a problem, or writing a computer program. Whether spoken, written or mechanised, L